Sound Advice

A Guide to Hearing Conservation Programs

WorkSafeBC

2024 Updates to Sound Advice

This insert describes key changes that affect the content of *Sound Advice* since its publication in 2017.

These changes are based on recent updates to CSA Standard Z94.2 and CSA Standard Z1007.

Updates

Page 31 | Daily noise exposure of workers

Changed

The CSA standard recommends a "class" system to help choose a hearing protector based on the worker's daily exposure. The standard also explains the use of the noise reduction rating (NRR), which is a system of labelling used in the United States. Hearing protectors are typically labelled with classes, NRRs, or both.

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The CSA standard recommends a "class" system to help choose a hearing protector based on the worker's daily exposure. The standard also explains the use of the noise reduction rating (NRR), which is a system of labelling used in the United States. Hearing protectors are typically labelled with classes, NRRs, or both. The CSA standard further recommends the use of field-attenuation estimation systems (FAESs), which provide a personal attenuation rating (PAR), to determine the level of hearing protection for an individual worker.

Page 32 | Noise reduction rating (NRR)

Changed

Effective rating calculations for NRR

Device type	For use with dBA
Earplugs	L_{ex} – (NRR × 0.5) – 3 = XX dBA
Earmuffs	L_{ex} – (NRR × 0.7) – 3 = XX dBA
Dual protection	L_{ex} – (NRR × 0.6) – 3 = XX dBA

For example, if the faller who is exposed to 102 dBA L_{ex} wants to use the NRR to select hearing protection and has an earmuff labelled with an NRR of 30, the calculation used to determine the hearing protection's effectiveness would be as follows:

$$102 \text{ dBA } L_{ex} - (30 \times 0.7) - 3 = 78 \text{ dBA}$$

This means the faller can assume that hearing protection with an NRR of 30 will provide optimal protection in this situation. (See the "Protection outcomes" table on page 34.)

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Effective rating calculations for NRR

Device type	For use with dBA
Earplugs	L_{ex} – [NRR(0.5) – 3] = XX dBA
Earmuffs	L_{ex} – [NRR(0.7) – 3] = XX dBA
Dual protection	L_{ex} – [(NRR+5)(0.65) – 3] = XX dBA Using the higher NRR of the two devices

Note: Use of the percentages of NRR achieved shown in this table is helpful in estimating average protection for groups of workers, but these de-ratings cannot be used to determine protection for an individual worker. Individual protection can only be estimated by using a field-attenuation estimation system, often referred to as "fit testing" (see page 38).

For example, say the faller who is exposed to 102 dBA L_{ex} wants to use the NRR to select hearing protection and has earmuffs labelled with an NRR of 26 and earplugs labelled with an NRR of 33.

If the faller wears both for dual protection, we use the higher NRR of the two devices (in this case, the NRR of 33 for the earplugs) and add 5 (due to the additional protection provided by the earmuffs). The calculation used to determine the estimated noise-exposure level while wearing the two hearing protection devices would be as follows:

$$102 \text{ dBA } L_{ex} - [(33+5)(0.65) - 3] = 80.3 \text{ dBA}$$

38

24.7

21.7

This means the faller can estimate that the exposure while using dual hearing protection will be 80.3 dBA.

If the faller wore only the earplugs labelled with an NRR of 33, the estimated noise-exposure level would be calculated as follows:

$$102 \text{ dBA } L_{ex} - [33(0.5) - 3] = 88.5 \text{ dBA}$$

Based on the NRR, the earplugs alone would not lower the exposure to safe levels (below 85 dBA).

If the faller wore only the earmuffs labelled with an NRR of 26, the estimated noise-exposure level would be calculated as follows:

$$102 \text{ dBA } L_{ex} - [26(0.7) - 3] = 86.8 \text{ dBA}$$

Based on the NRR, the earmuffs alone would not lower the exposure to safe levels (below 85 dBA).

Additions

Page 33 | New sections

The following new sections are added to page 33, before the section on "Continuous use versus non-continuous use."

Field-attenuation estimation systems (FAESs)

Field-attenuation estimation systems, commonly called "fit-testing systems," are recommended in CSA Standard Z1007:22. These systems have been developed to assess hearing protection attenuation for individuals. Fit testing can provide a more direct estimate of the protection individual workers can expect to receive from their hearing protection devices (HPDs).

Fit testing can assist with selecting appropriate hearing protection for an individual worker and monitoring its fit over time, as well as with training and motivating workers to properly fit their hearing protection.

Types of fit-testing systems

Several different fit-testing systems exist and can be classified as either subjective or objective.

Subjective systems' results are based on an individual's subjective response to a test signal.

Objective systems use a sensor to measure attenuation provided by an HPD.

Fit-testing systems should conform to the current version of ANSI/ASA Standard S12.71 and provide a personal attenuation rating or report a pass/fail.

Personal attenuation rating (PAR)

Many FAESs provide a median PAR (PAR_{50}) and combine the attenuation values for both ears. This binaural PAR should be subtracted from the A-weighted noise level or noise-exposure level to estimate the protection provided by the HPD. Some systems also report the PAR for each ear, which can be helpful for training workers to optimally fit their hearing protection. For more information, refer to CSA Standard Z1007:22.

For more information and resources, visit worksafebc.com/hearing-loss-prevention.

About WorkSafeBC

At WorkSafeBC, we're dedicated to promoting safe and healthy workplaces across B.C. We partner with workers and employers to save lives and prevent injury, disease, and disability. When work-related injuries or diseases occur, we provide compensation and support injured workers in their recovery, rehabilitation, and safe return to work. We also provide no-fault insurance and work diligently to sustain our workers' compensation system for today and future generations. We're honoured to serve the workers and employers in our province.

Prevention Information Line

We provide information and assistance with health and safety issues in the workplace.

Call the information line 24 hours a day, 7 days a week to report unsafe working conditions, a serious incident, or a major chemical release. Your call can be made anonymously. We can provide assistance in almost any language.

If you have questions about workplace health and safety or the Occupational Health and Safety Regulation, call during our office hours (8:05 a.m. to 4:30 p.m.) to speak to a WorkSafeBC officer.

If you're in the Lower Mainland, call 604.276.3100. Elsewhere in Canada, call toll-free at 1.888.621.7233 (621.SAFE).

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WorkSafeBC

Health and safety resources

You can find our health and safety resources on worksafebc.com, and many of them can be ordered from the WorkSafeBC Store at worksafebcstore.com.

In addition to books, you'll find other types of resources at the WorkSafeBC Store, including DVDs, posters, and brochures. If you have any questions about placing an order online, please contact a customer service representative at 604.232.9704 or toll-free at 1.866.319.9704.

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Contents

Introduction

Noise is a serious and widespread problem in many workplaces. Over time, if noise from machinery, processes, and equipment is too loud it can cause permanent hearing loss in workers. But occupational hearing loss can be prevented if employers, supervisors, workers, and WorkSafeBC work together to control noise exposure.

The most effective way to do that — and to protect worker hearing — is to implement a noise control and hearing conservation program. Such a program is required whenever noise is above regulated limits.

This manual does not replace the Occupational Health and Safety Regulation

This manual explains the requirements of a noise control and hearing conservation program that will benefit both workers and employers. It's designed to give you a basic understanding of health and safety requirements, but you should also refer to the Occupational Health and Safety Regulation to be sure you're meeting your legal responsibilities for workplace health and safety. You can find a searchable version of the Regulation and its accompanying Guidelines at worksafebc.com (click "Law & Policy").

In this manual, the word *must* indicates a requirement that's specified in the Regulation. The word *should* indicates a recommended action that will improve workplace safety even though it's not required by the Regulation.

This manual provides general information on hearing conservation programs. Some program requirements, such as noise measurement and noise control, call for specialized technical knowledge and must be undertaken by qualified people.

CSA standards — revision dates

Throughout this manual, you will see references to CSA standards. The titles of CSA standards include numbers indicating the year the standard was created or revised. For example, *CSA Standard Z94.2-14* was revised in 2014. Because the standards are revised periodically, make sure you're referring to the most recent version.

Hearing conservation programs

When noise exceeds regulated limits, employers must have an effective hearing conservation program in place. In British Columbia workplaces, the allowable limit is 85 decibels (dBA) over an eight-hour period. For impact noises, such as pile driving or hammering, a 140 dBC peak sound level must not be exceeded.

Hearing conservation programs are meant to reduce workers' exposure to noise and prevent occupational hearing loss. Hearing conservation programs must include the following elements:

- Noise measurement
- Education and training
- Engineering controls
- Hearing protection
- Posting of noise-hazard areas
- Hearing tests
- Annual program review

Starting a hearing conservation program

Starting a hearing conservation program isn't difficult. If your workplace requires such a program, follow these basic steps to get started:

- Conduct a noise survey, either in-house or by hiring a consultant, or determine whether an exemption applies (see page 10).
- Consider engineering controls that eliminate or reduce noise.
- Consider administrative controls that reduce the time workers spend doing noisy tasks.

Reducing noise to safe levels or limiting exposure may eliminate the need for further action. However, if workers are still exposed to noise above the regulated limits, follow these steps:

- Inform workers that a program will be implemented and educate them about the program.
- Contact WorkSafeBC for relevant educational resources.
- Provide several hearing protection options for workers and educate them on how to use them. One size does not fit all.
- Organize hearing tests using an in-house tester or hire an industrial audiometric hearing tester.

Note: Employers are responsible for the cost of hearing tests and any necessary hearing protection equipment.

For information on developing a management process for your hearing conservation program, see *CSA Standard Z1007-16, Hearing Loss Prevention Program (HLPP) Management.*

Hierarchy of controls

Some control methods are more effective than others. It may not always be practicable to use the more effective solution, but whenever possible you must implement controls in the following order:

1. **Eliminate the hazard entirely or substitute materials or processes to reduce the hazard.** The best way to reduce the risk of noise exposure is to eliminate the source of noise.
2. **Use engineering controls.** For example, reduce noise at the source by retrofitting equipment with noise-control devices (see pages 17–22).
3. **Use administrative controls.** For example, limit the time workers spend around noisy machines (see page 23).
4. **Use personal protective equipment (PPE).** For example, supply workers with hearing protection, such as earplugs or earmuffs, and make sure they know how to use them properly (see pages 24–30).

Noise measurement

What's the difference between dB and dBA?

Sound intensity, which is perceived as loudness, is measured in units called decibels (dB). Sound level meters have built-in filters. The unit dBA refers to decibels measured on a sound level meter using the A-weighting filter, which mimics the way the human ear responds to sound. Occupational noise surveys must be measured in dBA.

Employers are responsible for identifying workers at risk of noise overexposure. The Regulation specifies exposure limits of 85 dBA L_{ex} or a peak noise level of 140 dBC.

When workers are, or may be, exposed to noise above 82 dBA L_{ex}, employers must conduct a noise survey, unless an exemption applies (see page 10). How loud is 82 dBA? If you have to raise your voice to carry on a conversation, then the noise level is likely more than 82 dBA.

Measuring workplace noise will help you do the following:

- Identify significant sources of noise so you can prioritize which ones should be controlled first.
- Identify workers who require hearing protection, hearing testing, education, and training.
- Determine which workplace areas should be designated as hazardous noise areas.

What do L_{eq} and L_{ex} mean?

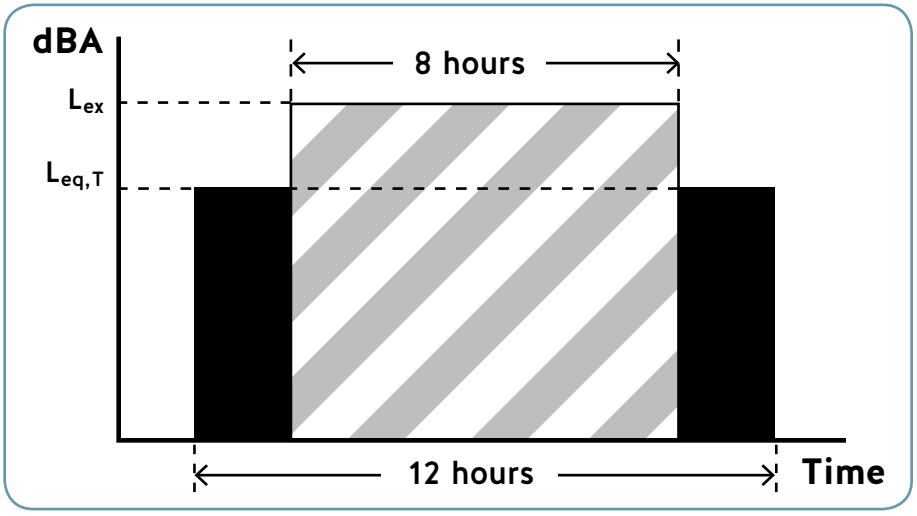
The risk of hearing loss depends on the noise level and duration of exposure. Noise measurements must include information about both. Noise levels vary throughout the day, so to measure them you must use an integrating sound level meter that averages noise levels over time.

dBA L_{eq} is the measurement unit used to indicate the average noise level over a period of time. L_{eq} measurements include a number indicating the length of time over which the noise is measured. For example, L_{eq}10s indicates a 10-second measurement, and L_{eq}24h indicates a 24-hour measurement.

dBA L_{ex} is the noise level averaged over 8 hours (the duration of a typical workshift). An L_{ex} measurement is equal to L_{eq}8h. An L_{ex} can be calculated from a noise measurement of any duration and provides an equivalent to a measurement done over an 8-hour period.

L_{ex} measurements are used because not all workshifts are 8 hours. By converting the noise measurement of a specific duration to L_{ex}, you can compare it to noise measurements of other durations and to the allowable limit of 85 dBA L_{ex} specified in the Regulation.

The following illustration shows how a 12-hour L_{eq} measurement is converted to its L_{ex} equivalent. The wider block (representing 12 hours) and the narrower block (representing 8 hours) contain the same amount of sound energy. The L_{ex} of the 12-hour workshift — or any workshift longer than 8 hours — is greater than the measured L_{eq}. For shifts shorter than 8 hours, the L_{ex} will be less than the measured L_{eq}.



Maximum allowable exposure times

The exposure times in the following table are all equivalent (i.e., they are all 85 dBA L_{ex}).

Duration of exposure	Noise level
16 hours	82 dBA
12 hours	83 dBA
8 hours	85 dBA
4 hours	88 dBA
2 hours	91 dBA
1 hour	94 dBA
30 minutes	97 dBA
15 minutes	100 dBA
7 minutes, 30 seconds	103 dBA
3 minutes, 45 seconds	106 dBA
1 minute, 50 seconds	109 dBA
1 minute	112 dBA
30 seconds	115 dBA

3 dB exchange rate

Sound measured in decibels increases or decreases exponentially. For every 3 dB that a sound increases, there's twice as much energy or power in it (it's twice as "intense"). Even though the human ear doesn't perceive the noise level to be twice as loud, it's twice as hazardous or damaging. A 3 dB reduction is half as intense. This is called the 3 dB exchange rate. This is why 85 dBA for 8 hours is equivalent to 88 dBA for 4 hours.

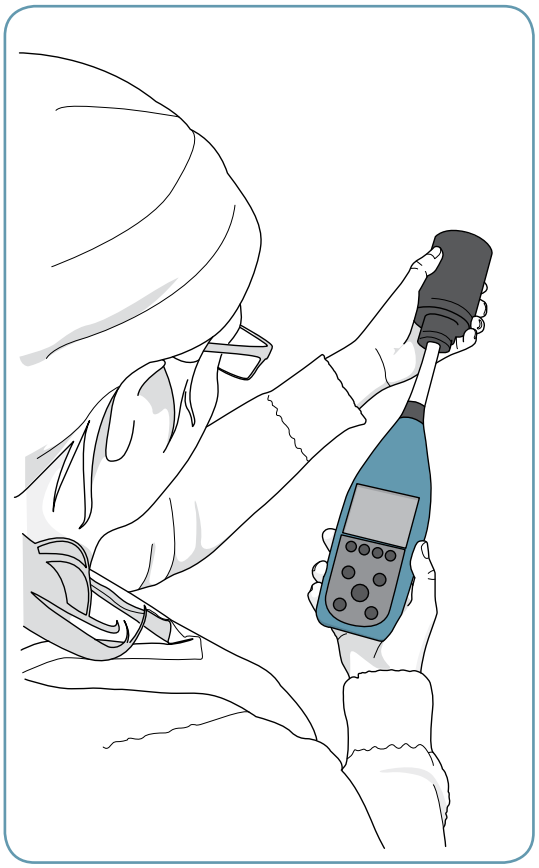
Types of noise measurements

You can use area noise measurements or spot measurements to determine if there's a need for further measurement or to verify that a hearing conservation program is necessary. *Area noise measurements* measure general noise levels in a work area. *Spot measurements* measure noise levels near a specific piece of equipment or during a specific work process.

Personal exposure measurements measure a particular worker's exposure. Area measurements and spot measurements are not a substitute for personal exposure measurements because area and spot readings don't incorporate information about the duration of exposure. Area measurements may overestimate or underestimate a worker's noise exposure. This can lead to inappropriate selection of hearing protection and inaccurate identification of workers who must be included in the hearing conservation program and who require annual hearing tests.

Noise-measuring equipment

Noise surveyors use integrating sound level meters and noise dosimeters to measure noise exposure. Both instruments average noise levels over time to provide an L_{eq} measurement. Integrating sound level meters are hand held. Noise dosimeters are small devices workers wear with a microphone typically placed on the worker's shoulder or collar.



Integrating sound level meters average noise levels over time. To ensure proper function, these should be calibrated before and after a survey.

Workers wear noise dosimeters over the shoulder or on the collar.

Smartphone apps

Smartphone apps are not a substitute for integrating sound level meters or dosimeters. Smartphone apps and microphones vary in accuracy and can't be calibrated properly. They can, however, be used to indicate whether further sound level testing is required, similar to area and spot measurements.

It's best to assume that the measurement has a large margin of error, as much as ±10 dB. This means that if a smartphone app measures 75 dBA, you should conduct measurements with a calibrated sound level meter or start a hearing conservation program.

Measuring noise levels

Who should conduct noise measurements?

Noise measurements should be done by knowledgeable, trained personnel, such as in-house health and safety staff, or by an acoustical consulting firm (search online for "acoustical consultants"). Either way, you will need to make sure they are familiar with, and can meet, the requirements of both *CSA Standard Z107.56-13, Procedures for the Measurement of Occupational Noise Exposure* and the WorkSafeBC publication *Occupational Noise Surveys*.

Calibrating measuring equipment

It's important to calibrate measuring equipment (i.e., dosimeters and sound level meters). Calibration will ensure the equipment is functioning properly and reading noise levels accurately. Calibrating equipment for a survey is known as field calibration. Field calibration must be done before and after measurements using an acoustical calibrator.

A complete calibration of measuring equipment, including the acoustical calibrator used in the field, should be done in a properly equipped laboratory annually, or as indicated by the manufacturer. A laboratory calibration will thoroughly check all functions to ensure the equipment is working correctly.

Conducting measurements

When conducting measurements, position the microphone in the worker's hearing zone. The microphone needs to be close enough to the worker's ear to get a reliable measurement of noise exposure. When using a dosimeter, clip the microphone to the worker's collar or shoulder, on the side with the most noise exposure.

When measuring noise levels (for example, with a sound level meter, as shown in the illustration), position the microphone in the worker's hearing zone on the side where there's the most noise.

It may not be necessary to measure noise for an entire shift. A worker's noise dose can be calculated from measurements over shorter periods, provided the measurements represent the worker's exposure throughout the day.

To ensure the measurements represent current conditions, the noise surveyor should ask managers, supervisors, and workers the following questions:

- What are the major noise sources, noisiest areas, and previous complaints?
- How does the work pattern compare to a typical workday? Do the noise levels change? What are the number and duration of breaks? Is there downtime, or are there delays, product changes, or job rotations?
- If noise isn't measured on a typical day, how does that affect the measurements and will measurements need to be redone?
- Has noisy equipment been added, removed, or modified since the last noise measurements were taken?
- Have noise-control measures been implemented?

Noise measurements must be carried out according to acceptable standards. *CSA Standard Z107.56-13, Procedures for the Measurement of Occupational Noise Exposure*, provides guidance on the type of equipment to use, which workers to test, and how to test. For more information on noise-measurement techniques and sampling strategies, see the WorkSafeBC publication *Occupational Noise Surveys*.

Exemptions from noise-measurement requirements

> **Note**
>
> The exemption from noise-measuring requirements only applies if an effective hearing conservation program is implemented.

If other information indicates that workers are being exposed to noise levels above the exposure limits and an effective hearing conservation program is in place, employers don't have to measure workers' noise exposure. Other information indicating that workers are exposed to noise over the exposure limits may include the following:

- Labels on tools or specifications for equipment indicate there's a strong likelihood of overexposure to noise resulting from using the equipment.
- A database of worker noise exposures indicates most members of a trade are overexposed on a daily basis. (The WorkSafeBC Hearing Loss Prevention Section has such a database.)
- Short-term noise measurements suggest the L_{ex} of 85 dBA is exceeded daily (for example, a measurement of 100 dBA for 15 minutes a day).
- Spot or area measurements — or measurements taken with a non-integrating sound level meter, smartphone app, or noise "indicator" — suggest the L_{ex} of 85 dBA is exceeded daily.
- The peak noise-level limit of 140 dBC is exceeded daily.

If no previous information on sound levels exists and workers could be overexposed to noise, the employer must ensure that a noise survey is completed.

Noise-survey records

The results of a noise survey must be documented in a written report. The report can follow any format, but it should include the following information:

- A list of jobs where there's overexposure to noise as specified in the Regulation and where workers must be included in a hearing conservation program (with hearing protection and annual hearing tests)
- Locations that must be posted with signs warning about high noise levels and the requirement for hearing protection
- A statement that the measurements were taken under typical noise conditions
- The dates of the measurements and the noise-measuring equipment used
- If necessary, explanations to account for unusual or different noise levels resulting from changes in the daily work routine
- An explanation of the calculation method used if total daily noise exposures were calculated from partial noise exposures

In addition to a written report, it may be useful to summarize the noise-survey information in a table (see example on pages 12–13) or indicate the noise levels on a map of the plant (see example on page 14).

Employers must ensure that the current noise-measurement results are available to WorkSafeBC officers and the company's joint health and safety committee (or worker health and safety representative, if applicable).

When should noise measurements be redone?

You should redo noise-exposure measurements if noise exposure may have changed because of any of the following:

- Machinery was installed or removed.
- The workload or equipment-operating conditions changed, causing a significant increase in noise levels.
- The building structure changed (for example, a wall was removed or added).
- Work processes or tasks changed (for example, the time workers spend in noisy areas has changed).

Example of summarized survey information

Company name: Peacham Pill Co. Ltd.

Division/department: Manufacturing

Address: 221A Holmes Street, Burnaby, BC, V1E 2T4

Worker name or job	Number of workers	L_{eq} dBA	Shift duration (hours)	L_{ex} dBA	Comments	Okay with regulations? (Y/N)	Recommendations
Bottling							
Feeder	1	83.5	10	84.5	• All measurements were for 4 hours and representative of entire day • L_{eq} converted to L_{ex} (according to *Basic Noise Calculations**) • Steady noise for long periods • No significant impact noise	Y	• Make hearing protection available
Filler	1	85.5	10	86.5		N	• Implement noise controls, such as engineering or administrative controls • Consider job rotation to reduce average L_{ex} to less than 85 dBA L_{ex} • If duration changes, redo dosimetry
Capper	1	81	10	82		Y	• Make hearing protection available
Labeller	2	80	10	81		Y	• No action required
Packer	5	78.5	10	79.5		Y	• No action required
Tablet pressing							
Acme press #1	1	89	7	88.5	• L_{eq} 4 hours, representative of entire shift • L_{eq} converted to L_{ex} (according to *Basic Noise Calculations**)	N	• Hearing conservation and noise control program

Worker name or job	Number of workers	L_{eq} dBA	Shift duration (hours)	L_{ex} dBA	Comments	Okay with regulations? (Y/N)	Recommendations
Acme press #2	1	93.5	7	93	• 7-hour dosimetry • L_{eq} converted to L_{ex} (according to *Basic Noise Calculations**) • Significant impact peaks = 133 dBC	N	• Hearing conservation and noise control program
Acme press #3	1	93.5	8	93.5	• 4-hour dosimetry, representative of entire shift • Significant impact peaks = 138 dBC	N	• Hearing conservation and noise control program
Shipping							
Forklift	1	82.2	12	84	• 4-hour dosimetry, representative of entire shift • L_{eq} converted to L_{ex} (according to *Basic Noise Calculations**) • Variable level • No significant impact noise in shipping	Y	• Make hearing protection available • Install new muffler on forklift
Truck driver	1	79	12	81		Y	• No action required

* For more information on the publication *Basic Noise Calculations*, see WorkSafeBC Resources, page 50.

Noise surveyor: A.N. Other

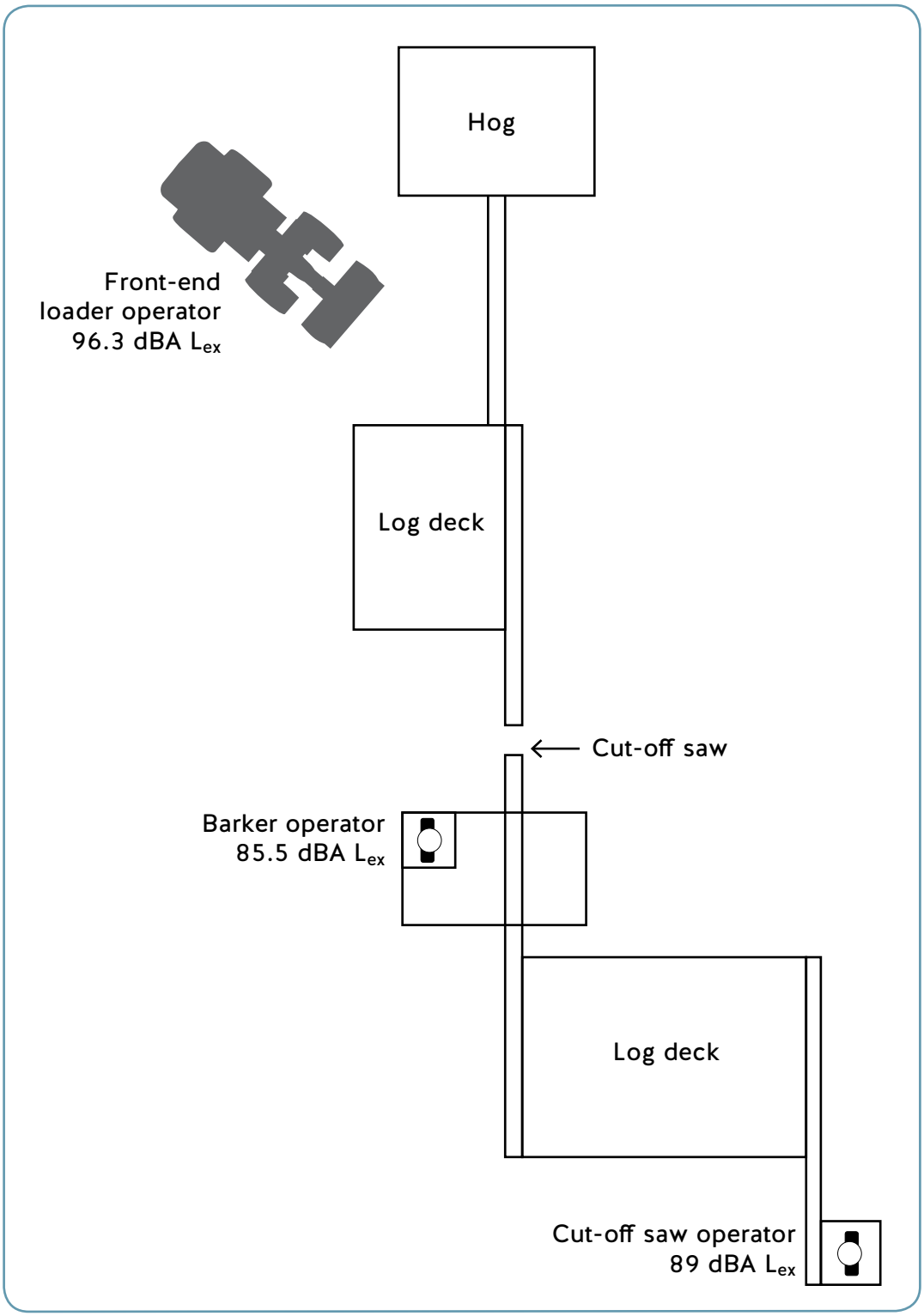
SLM/dosimeter: Valiant **Model:** N1S/N: XYZ1234 **Signature:**

Calibrator: Valiant **Model:** N2S/N: ABC987 **Survey date:** 2017-09-05

Calibrated: January 15, 2017

Example of a general layout diagram

The following diagram shows a partial sawmill layout with worker noise exposures.



Education and training

WorkSafeBC resources

Employers and safety committees are encouraged to consult with WorkSafeBC Hearing Loss Prevention staff about the content and design of an education and training program for workers. WorkSafeBC also has resources on hearing conservation. See page 50 for information on these resources.

Employers are responsible for ensuring workers understand the noise hazards they're exposed to and how to protect their hearing. Where noise surveys are done, you must inform workers of the results and of the possible risk of hearing loss.

When noise exceeds the exposure limits (85 dBA L_{ex} or 140 dBC peak), you should inform workers about the following:

- Results of the noise survey, unless an exception applies, as specified in section 7.4 of the Regulation
- Effects of noise on hearing, including how noise outside of work hours can contribute to overexposure (for example, listening to music)
- Purpose of annual hearing testing
- Proper use and maintenance of hearing protection

Employers can incorporate this education and training into short crew talks. It should also be part of the health and safety training provided to new employees.

Annual hearing tests

Required annual hearing tests are another opportunity for worker education. Workers must receive individual counselling from the audiometric technician on their hearing-test results. Annual hearing tests are a good time to do the following:

- Review the use and care of workers' hearing protection.
- Reinforce information about the effects of noise on hearing and the purpose of hearing testing.

If your company has in-house audiometric technicians, they must have adequate training and attend periodic refresher courses to be authorized to conduct hearing tests. These courses include training on how to select, fit, and use hearing protection, as well as how to submit test results to WorkSafeBC.

Employers can access test results by going to worksafebc.com, clicking "Log in/Create an account," and then searching for "IAS" or "industrial audiometric system."

Other staff

Education and training are also required for:

- Supervisors
- Anyone involved in administrating the hearing conservation program
- Those who issue and fit hearing protection

Supervisors should be educated about hearing conservation so they can monitor the use and condition of hearing protection and ensure workers attend their scheduled annual hearing tests.

Engineering controls

The most effective way to deal with workplace noise is to reduce it by using engineering controls. Engineering controls are the arrangement, design, or alteration of the physical work environment, equipment, or materials. For example, a partial operator booth is an engineering control that helps protect graders in sawmills against noise overexposure while still allowing them to handle lumber.

At best, engineering controls can eliminate the need for hearing protection, hearing testing, and other elements of a hearing conservation program. Even if engineering controls alone aren't enough to reduce noise to safe levels, they may reduce the noise to a point where workers wearing hearing protection are safe from overexposure. Although 3 dB might not seem like a lot, it can make an important difference. If the noise can be reduced by 3 dB, it's half as intense.

Employers must investigate engineering-control options when workers are exposed to noise above the exposure limits. This requires a knowledgeable professional, such as an acoustical engineer. Engineers should get information from appropriate staff who understand the operational requirements of the workplace.

When practicable, employers must implement one or more engineering controls to reduce noise exposure below the exposure limit. You may need a combination of noise-control methods, such as acoustical treatment of the room and a partial machine enclosure. This section describes several engineering-control options.

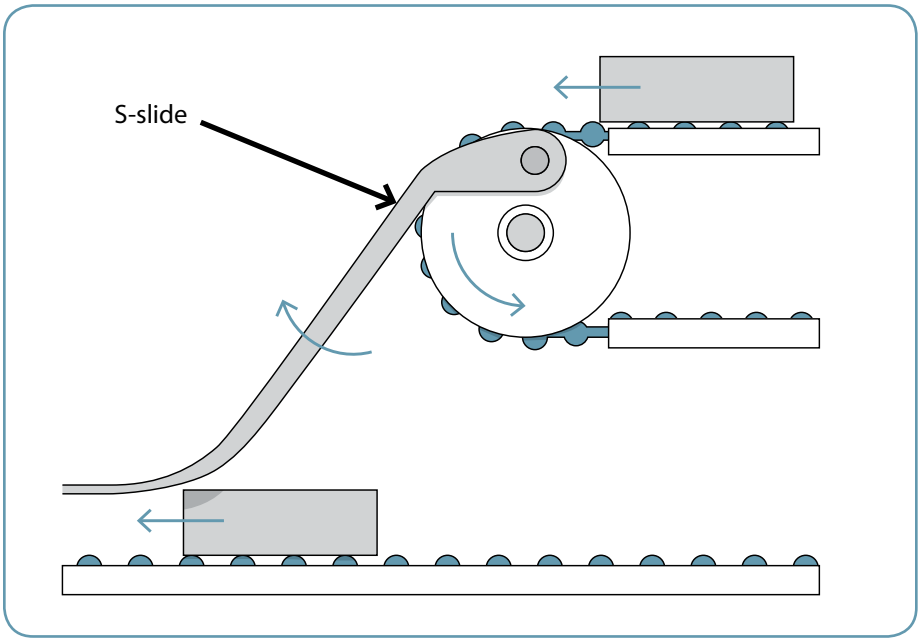
Reducing noise at the source

You can avoid many potential noise hazards by choosing quieter equipment. When purchasing new equipment, check the specifications to see if there's a limit on the noise generated or a requirement for the vendor to provide noise-performance data. If noise is not engineered out during the design stage, you may be able to retrofit the equipment with noise-control devices, such as mufflers, silencers, special nozzles, or isolators.

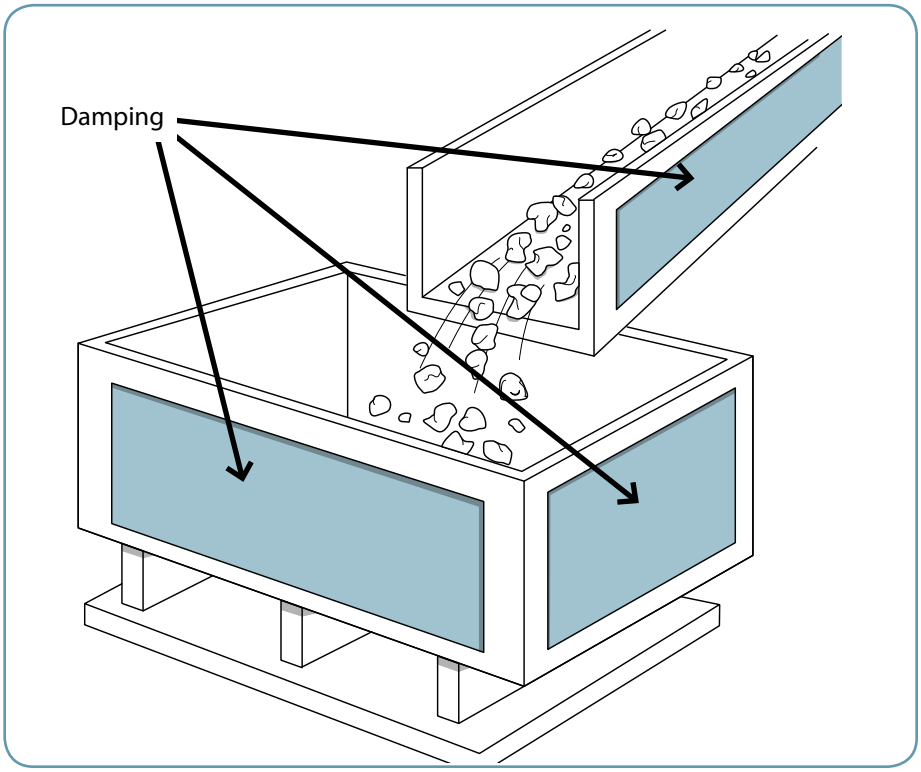
Using quieter equipment components can also help reduce noise at the source. For example, substituting a large slow-speed fan for a smaller high-speed fan can reduce noise.

When buying mobile equipment, specify that sound levels in the cab should be below 85 dBA. The higher initial cost of soundproofed mobile equipment could be lower than the cost of retrofitting the cab with special materials and devices.

Materials handling can generate a surprising level of noise. Although conveyor speeds typically can't be changed for productivity reasons, drop heights can often be reduced. Impact points can be fitted with long-wearing rubber or plastic cushions that reduce noise.



An S-slide will reduce drop height and deliver material quietly.



Installing damping in delivery chutes and bins will reduce noise.

Compressed-air exhausting from door or gate actuator ports also generates noise. Installing exhaust silencers or hoses or pipes that move exhaust air (and noise) away from the work area may reduce noise levels.

Another common noise source is air jets that are used to cool, dry, move, or clean objects. Changing the air nozzle may reduce the noise by up to 20 dB while also reducing the compressed-air flow requirements.

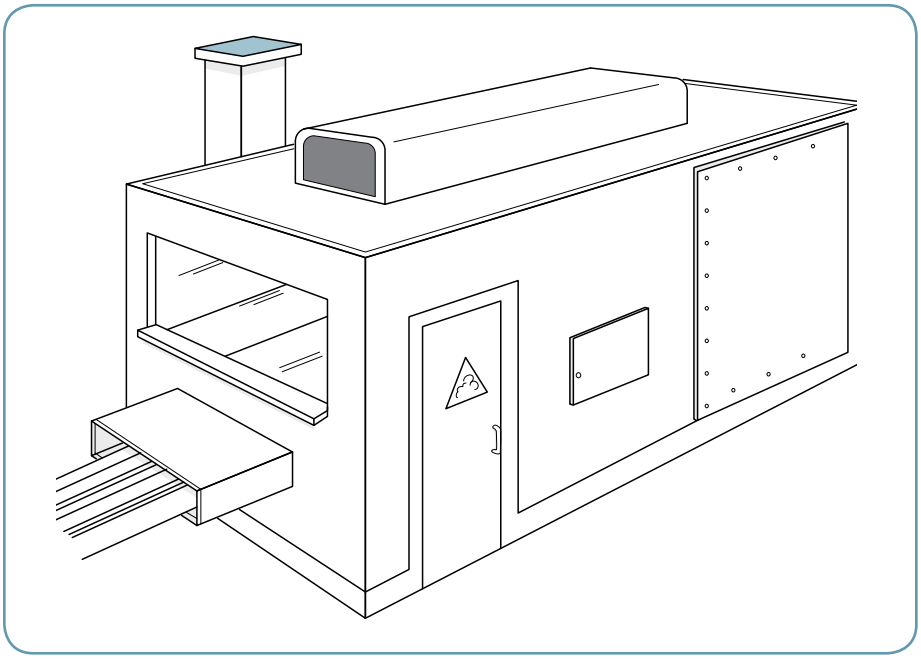
Sheet-metal panels, when struck, can produce significant noise through vibration. Damping the vibrations can reduce the noise. For example, vibration damping on punch-press collection and delivery chutes can reduce noise by 5 to 10 dB.

Some pneumatic hand tools are very noisy. When possible, purchase tools designed to operate more quietly.

Enclosing the noise source

Enclosing the noise source is especially useful when the enclosure doubles as a safety guard or an environmental control device. Enclosures reduce noise exposure by acting as a barrier and sound absorber. Noise enclosures commonly reduce noise by 25 dB. The ceiling and walls of the enclosure should be lined with sound-absorbing material. Otherwise, noise will reverberate inside the enclosure and escape through small openings, often to locations where there are workers. Enclosure openings should be as small as possible.

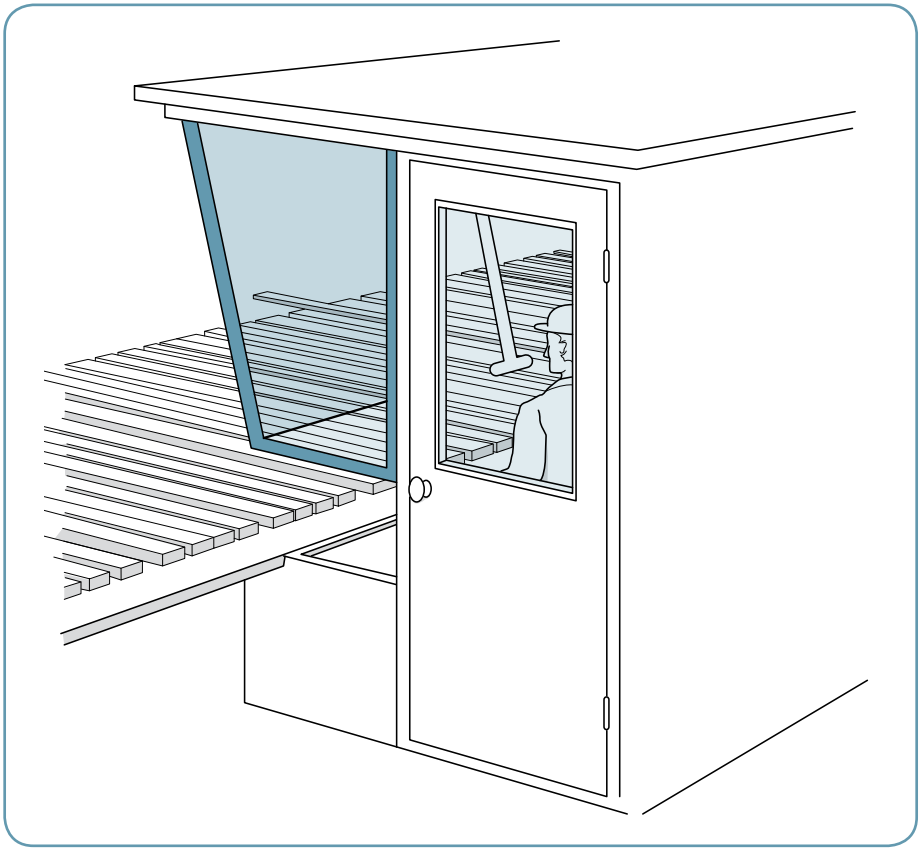
Machines with solid safety panels can often be modified to convert the guarding into effective local noise enclosures. For example, the engine compartments of trucks and buses can be lined with sound absorbers on the bulkhead and hood.



Enclosing machinery will reduce noise levels.

Enclosing workers

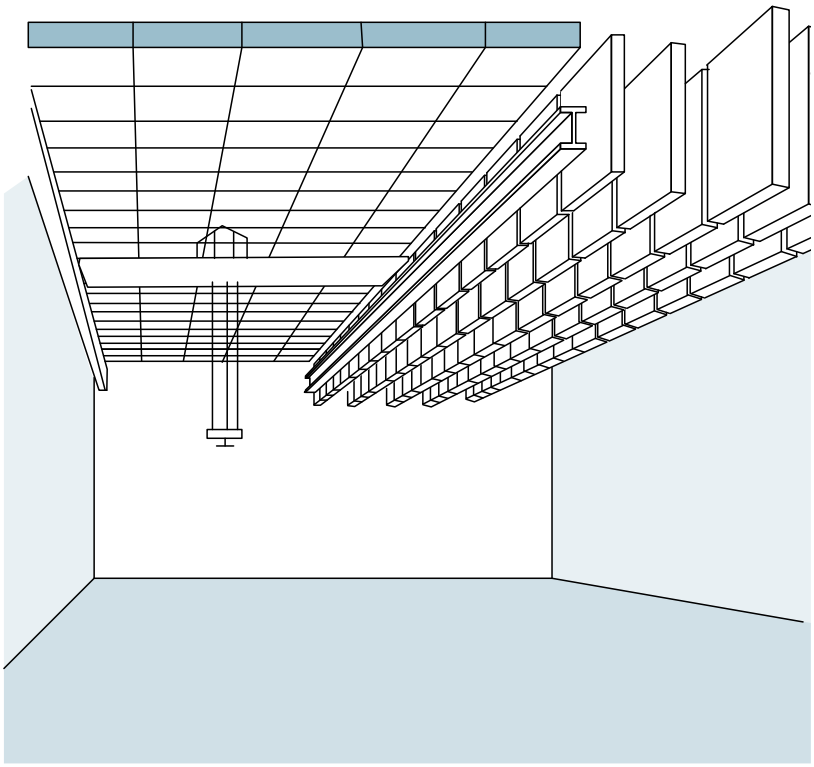
Enclosing workers in booths is practical when workers leave the enclosure only occasionally (for example, to make adjustments or clear trapped material). Operator booths can reduce noise levels significantly. A 20 dB reduction is typical. Partial operator booths are effective for graders in sawmills.



A partial operator booth helps reduce noise levels while allowing the operator to handle material.

Acoustically treating the room

Lining the walls and ceiling with sound-absorbing panels or hanging baffles reduces reflected noise. This type of control doesn't interfere with access to machinery or require special building structures. However, direct noise will remain a problem close to the noise source where workers are usually stationed. Typically, acoustical treatments of rooms reduce noise by only 2 to 5 dB, but all workers in the room will experience the reduction.



Sound-absorbing baffles help reduce reflected noise.

Separating workers from the noise source

Noise levels decrease the further away a worker is from the noise source. The rate at which noise is reduced with distance increases when a room is acoustically treated, which means even more noise can be absorbed. Keep this in mind when designing new facilities and planning workstation locations.

Administrative controls

Documenting noise-reduction results

If you've implemented engineering or administrative controls, you should measure the noise reduction and document the results. This will help demonstrate compliance with the Regulation and may be useful when dealing with other noise-control hazards.

If engineering controls are not practicable, the next best way to deal with noise is through administrative controls. Administrative controls can also be used in combination with engineering controls to minimize noise exposure.

Administrative controls alter the way work is done. They include timing of work, policies and rules, and safe work practices (including training, housekeeping, and equipment maintenance). Examples of administrative controls include the following:

- Limit the time workers spend around noisy machines.
- Operate noisy machines during shifts with fewer workers.
- Provide quiet areas where workers can take a break from noise sources.
- Create safe work practices or safe operating procedures for working around noise sources.
- Post noise-hazard warning signs.

Reducing the duration of exposure

Work-related hearing loss results from noise level and duration of exposure. Reducing the time workers are exposed to noise can reduce exposure below allowable limits. For example, a worker exposed to 86 dBA for four hours could exchange jobs with another worker for the rest of the shift. If the noise level for the second half of the shift is 80 dBA, the total exposure for the full shift for both workers would be 84 dBA L_{ex}. Changing tasks during a shift is an example of an administrative control. Workers on canning and bottling lines, for example, can change workstations during their shifts to help reduce noise exposure.

Hearing protection

Keep hearing protection in place in noisy work areas

It's important for workers to put on or insert hearing protection before entering noisy environments and to leave it in place until they've left the noisy environment.

When engineering and administrative controls aren't enough to reduce noise exposures below exposure limits, hearing protection can provide a secondary means of reducing noise exposure. Employers must provide hearing protection for workers who are exposed to sound levels greater than 85 dBA L_{ex} or its equivalent. You're responsible for knowing which workers are overexposed to noise and which must wear hearing protection.

Hearing protection must be provided and selected according to *CSA Standard Z94.2-14, Hearing Protection Devices – Performance, Selection, Care, and Use.* For more information, see "Selecting hearing protection," pages 31–36.

Hearing protection devices

Hearing protection devices reduce the noise reaching the ear. The two main types of protection are earplugs and earmuffs. Earplugs may be inserted into the ear canal or placed over the ear canal.

Earmuffs have dome-shaped cups that cover the entire ear. They're either held in place by a spring-loaded headband or attached to a hard hat.

Earplugs and earmuffs reduce noise, but this includes all sounds — not only unwanted noise but also sounds that workers may need to hear, such as voices and warning bells. It's important to make sure hearing protection is not overprotecting. See "Effective protection versus overprotection," page 34.

Don't modify hearing protection

Never alter hearing protection. For example:

- Don't add ventilation to earmuffs. If they're too hot, consider earplugs.
- Don't modify the size or shape of earplugs. If they're uncomfortable, try a different size.
- Don't create a hole to attach audio cords to hearing protectors. If you want to listen to radio or another audio device, get hearing protection that has a direct audio input.

Earplugs

Earplugs are inserted into the ear canal or placed over the ear canal to form a seal and block sound. They can generally be categorized as compressible foam, push-to-fit, semi-insert, and custom-moulded.

Properly inserted earplugs shouldn't be painful. The most common problem with earplugs is when they aren't seated deeply enough in the ear canals. Partial insertion results in poor noise reduction, poor retention, and discomfort. When earplugs are properly inserted, there will be a slight sensation of pressure and the wearer's voice will sound louder and more resonant. There will also be some resistance when the wearer pulls gently on the earplug.

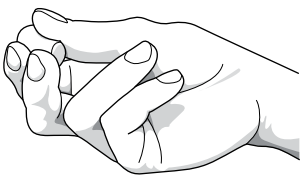
Workers should be individually instructed on how to insert earplugs. Instruction often occurs during the annual hearing test. Supervisors should also be taught to recognize improperly seated plugs and to instruct workers on the correct way to insert them.

Compressible foam earplugs

Foam earplugs are usually made of compressible foam. One size fits most workers, but it might not work for everyone. If a worker's ear canals are too small for a comfortable fit, the plug won't stay in place. Some compressible plugs come in several sizes.

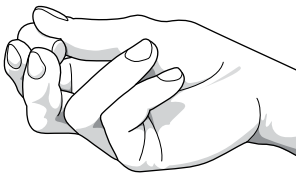
To insert a foam earplug, roll it between your fingers to compress it, then insert it into your ear canal and hold it there until the foam expands to fill the canal. It's important to straighten your ear canal by pulling on the outer ear with your other hand. If you don't straighten the canal, the plug will stick out too far to be effective.

1.



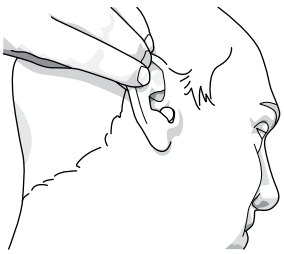
Roll the compressible earplug between your fingers before inserting it.

2.



Start rolling gently to prevent creases. Press more firmly as the plug is compressed.

3.



Straighten your ear canal as you insert the plug. Reach around your head with your other hand to lift your ear up and back.

4.

If the plug is fitting well, it should be invisible or barely visible from the front. Your voice should sound muffled to you, and the plug should feel snug.

Compressible foam plugs can become dirty when rolled before insertion. Workers whose hands tend to get dirty on the job can opt for reusables, such as push-to-fit plugs, or custom-moulded plugs.

Push-to-fit earplugs

Push-to-fit earplugs typically come in one size. They may be made of foams similar to those used in compressible foam earplugs. They may also be made of pre-moulded flexible plastic with single, double, or triple ridges that help seal the ear canal. Push-to-fit earplugs have a flexible stem for pushing and twisting the plug into the ear canal.

To properly insert the plug, straighten your ear canal and insert it with a slight twisting motion. The plug should not fall out, and you should feel some resistance if you gently pull on it. It should not pull out easily.

Push-to-fit earplugs are suitable for workers who may have dirty hands because they don't have to touch the portion of the plug that enters the ear canal.

Semi-insert earplugs

Semi-insert earplugs are also known as banded earplugs, semi-aural earplugs, or canal caps. Semi-insert earplugs are held in place by a spring-loaded headband worn either over the head, behind the head, or under the chin, depending on the manufacturer. The cap, or pod, fits over the opening of the ear canal. It shouldn't be inserted into the canal. The size of a worker's ear canal is not as important when fitting these devices. Semi-insert earplugs are widely used by workers who have intermittent or interrupted exposure to noise.

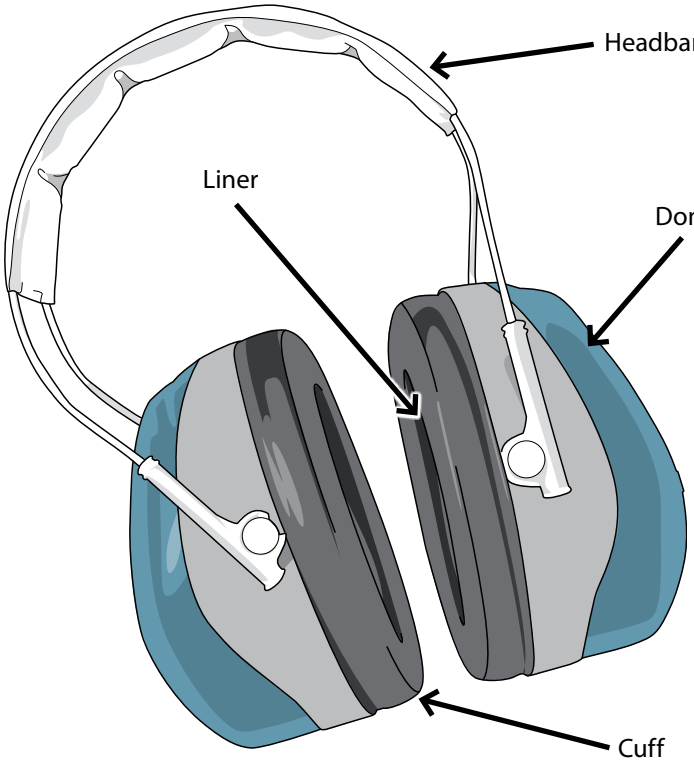
Custom-moulded earplugs

Custom-moulded earplugs are made by taking an impression of a worker's ear and creating a mould, which is used to cast the plug. It's vital that the impression of the ear is accurate or the finished plugs won't fit well. For effective protection, they should fit the ear snugly. These plugs can be difficult to insert because of their unusual shape, so workers need to be shown how to insert them properly. A worker will need new earplugs if the external ear and ear canal change shape with age or with extreme weight gain or loss. Custom-moulded earplugs should be replaced every three to five years. Check with the manufacturer.

Earmuffs

Earmuffs have four parts:

- **Domes (ear cups)** — These deflect noise. The deeper and heavier the dome, the greater the noise reduction. Domes are usually made of plastic.
- **Dome liners** — The domes are lined with acoustical material, typically foam, which reduces noise reverberation inside the dome.
- **Cuffs (ear cushions)** — These may be filled with foam, gel, liquid, or a combination of foam and liquid. Liquid-filled cuffs may make wearing safety glasses more comfortable. Foam cuffs are lighter weight.
- **Headband** — Headbands may be made of plastic, metal, or a combination of both.



These are the key parts of a typical earmuff.

Depending on their design, earmuff headbands may be worn over the head, behind the head, or under the chin. Earmuffs may also be mounted on a hard hat. Hard hat-mounted earmuffs put less pressure on the sides of the head and are more comfortable than earmuffs with headbands. The attachment for a hard hat may fit into slots on the hard hat or clip onto the brim with an adaptor.

The adaptor must be the proper size to be effective and may vary according to the brand of hard hat.

Earmuffs mounted on hard hats are more comfortable than earmuffs with headbands.

Ensuring a proper seal and fit

The domes must fit over the entire ear to provide a proper seal. An earmuff's effectiveness is determined by the headband tension and fit of the domes over the ears. If headband tension decreases through routine use or deliberate modification, noise reduction decreases.

Safety glasses, caps, or facial hair may interfere with the seal of the dome. Workers should push hair behind the ears or pin it up out of the way. Thin frames for glasses are preferable to thick ones. Temple pads are available to improve the seal and decrease discomfort caused by the pressure of the dome against glasses. Workers should not wear thick cloth caps, toques, or knitted hats if the earmuff's headband has to fit over the cap.

Jaw size and head shape may also pose a fitting problem — some muffs may not fit properly against the sides of the head. In this case, try earplugs instead.

Some earmuffs are made to be worn a specific way to ensure a proper fit. The top and bottom may be recognizable either by the shape of the muffs or designated by the manufacturer's instructions.

Fitting earmuffs and monitoring their use

As with earplugs, fitting earmuffs individually during the annual hearing test will help ensure workers receive proper instruction on how to use the muffs. Workers should bring their hearing protection to their annual hearing re-test so the fit can be assessed yearly.

Supervisors should watch out for improperly worn muffs, particularly hard hat-mounted muffs in the "snap-out" position. This position reduces the pressure of the cuff on the ear, but is only meant to be used for short periods of time. The headband should also be flush with the top of the head.

Specialized hearing protection devices

Conventional hearing protection can distort or muffle speech, machine sounds, and warning signals. This can make communication difficult and result in safety issues around machinery. This is especially problematic for workers with hearing loss or those whose jobs have high listening demands, such as supervisors, tradespeople, instructors, or hospitality workers.

Many of these workers simply take the protection off, increasing their risk of hearing damage. To combat this, there are specialized products that enhance listening and provide effective noise reduction, also called attenuation. There are two main categories of specialized hearing protection devices: active and passive.

Active protection devices

Active protection devices use electronics to reduce noise at the ear and enhance awareness of surrounding activity. They typically require batteries, so it's important to make sure the batteries have power and to turn off the electronics when not in use. Active protection devices include the following:

- **Noise-attenuation communication headsets** — These are earphones encased in earmuffs or earplugs that allow the wearer to adjust the incoming signal with a volume control. When considering these headsets, choose products that won't amplify the signal to a hazardous level (over 85 dBA).
- **Active noise-reduction hearing protection devices** — These systems include a microphone that picks up sound outside the earmuff, an electronic circuit that processes the signal, and a small speaker that generates a signal that is out-of-phase with the incoming signal. When the incoming signal combines with its out-of-phase (or mirror-image) version, the incoming signal is

cancelled out. The system works for incoming sounds below 500 Hz, which means the signal-cancelling feature is effective for low-frequency or low-pitch sounds only.

- **Sound-restoration hearing protection devices** — With these devices, a microphone receives the incoming sound and amplifies it, usually up to a maximum of 85 dBA. If the incoming sound is already at or above 85 dBA, the amplifier shuts down and the protector reduces sound like a conventional earmuff. So, sounds below 85 dBA are amplified, and sounds at or above 85 dBA are attenuated.

Passive protection devices

The following protection devices use mechanical means, such as filters or dampers, to alter sound characteristics:

- **Flat or uniform protectors** — These earplugs or earmuffs have a sound channel and use a special filter to provide nearly equal attenuation at all frequencies. This results in a signal that sounds more natural. (The earplug versions are often called "musician's earplugs.") In contrast, conventional protectors reduce high frequencies more than low frequencies.
- **Frequency-sensitive protectors** — These earplugs or earmuffs (usually earplugs) have small openings in them that allow certain frequencies to pass through, while blocking other frequencies.
- **Amplitude-sensitive (or level-dependent) protectors** — These earplugs or earmuffs (usually earmuffs) provide a small amount of attenuation at low noise levels but provide more attenuation as noise levels increase. They're primarily used to protect against impact or impulse noise, such as gunfire.
- **Adjustable-attenuation protectors** — These come with a selection of filters, dampers, or cartridges that can be inserted into a vent or port in the protector, usually an earplug, to control how much sound is blocked.

Selecting hearing protection

With so many suitable options, selecting appropriate hearing protection isn't difficult. Employers must provide a variety of hearing protection, as specified in *CSA Standard Z94.2-14*. The CSA standard describes the following selection criteria:

- Daily noise exposure of workers
- Comfort
- Compatibility with other personal protective equipment
- Hearing ability of workers
- Communication demands on workers
- Anatomical variations
- Environmental factors, such as temperature and climate
- Physical constraints of workers or work activity

This section describes in more detail the CSA criteria you must consider when selecting hearing protection.

Daily noise exposure of workers

When selecting hearing protection, consider the worker's noise exposure. *CSA Standard Z94.2-14* has a selection guide that includes recommendations for the amount of sound reduction (or attenuation) of hearing protectors.

The CSA standard recommends a "class" system to help choose a hearing protector based on the worker's daily exposure. The standard also explains the use of the noise reduction rating (NRR), which is a system of labelling used in the United States. Hearing protectors are typically labelled with classes, NRRs, or both.

Class

The recommendation for the class of protection is based on a worker's eight-hour, averaged noise exposure, not a spot measurement of noise in a given area or near a particular machine. For example, a faller's chainsaw may produce noise levels up to 110 dBA. However, a typical faller's eight-hour noise exposure is 102 dBA because the worker doesn't have the saw running for eight hours continuously. There are breaks for things like lunch, coffee, and moving through the bush. The class of hearing protection would therefore be selected based on the faller's exposure of 102 dBA.

Earplugs and earmuffs may be Class A, B, or C, although Class C can be difficult to find in standard earplugs or earmuffs.

Selecting hearing protection devices based on class and noise exposure in dBA

Exposure = L_{ex},8 (dBA)	Recommended class
< 90	C
> 90 up to and including 95	B or BL
> 95 up to and including 105	A or AL
> 105	Dual*

* Dual hearing protection is required. Use a minimum of a Class B earmuff and a Class A earplug.

Noise reduction rating (NRR)

Another system of classifying hearing protection is the NRR. This system uses a single number to express the attenuation of the protector.

The NRR, which is determined through laboratory testing, has been widely recognized to overestimate the attenuation that can be achieved in real-world conditions. As such, the NRR is often de-rated. Various de-rating factors have been proposed. *CSA Standard Z94.2-14* provides guidance on de-rating the NRR and applying a correction factor.

Earplugs can be considered to provide 50% of their NRR. Earmuffs provide closer to 70% of their NRR. You should also subtract 3 dB to get an estimate of the protection in dBA.

Effective rating calculations for NRR

Device type	For use with dBA
Earplugs	L_{ex} – (NRR × 0.5) – 3 = XX dBA
Earmuffs	L_{ex} – (NRR × 0.7) – 3 = XX dBA
Dual protection	L_{ex} – (NRR × 0.6) – 3 = XX dBA

For example, if the faller who is exposed to 102 dBA L_{ex} wants to use the NRR to select hearing protection and has an earmuff labelled with an NRR of 30, the calculation used to determine the hearing protection's effectiveness would be as follows:

$$102\,\text{dBA}\ L_{ex} - (30 \times 0.7) - 3 = 78\,\text{dBA}$$

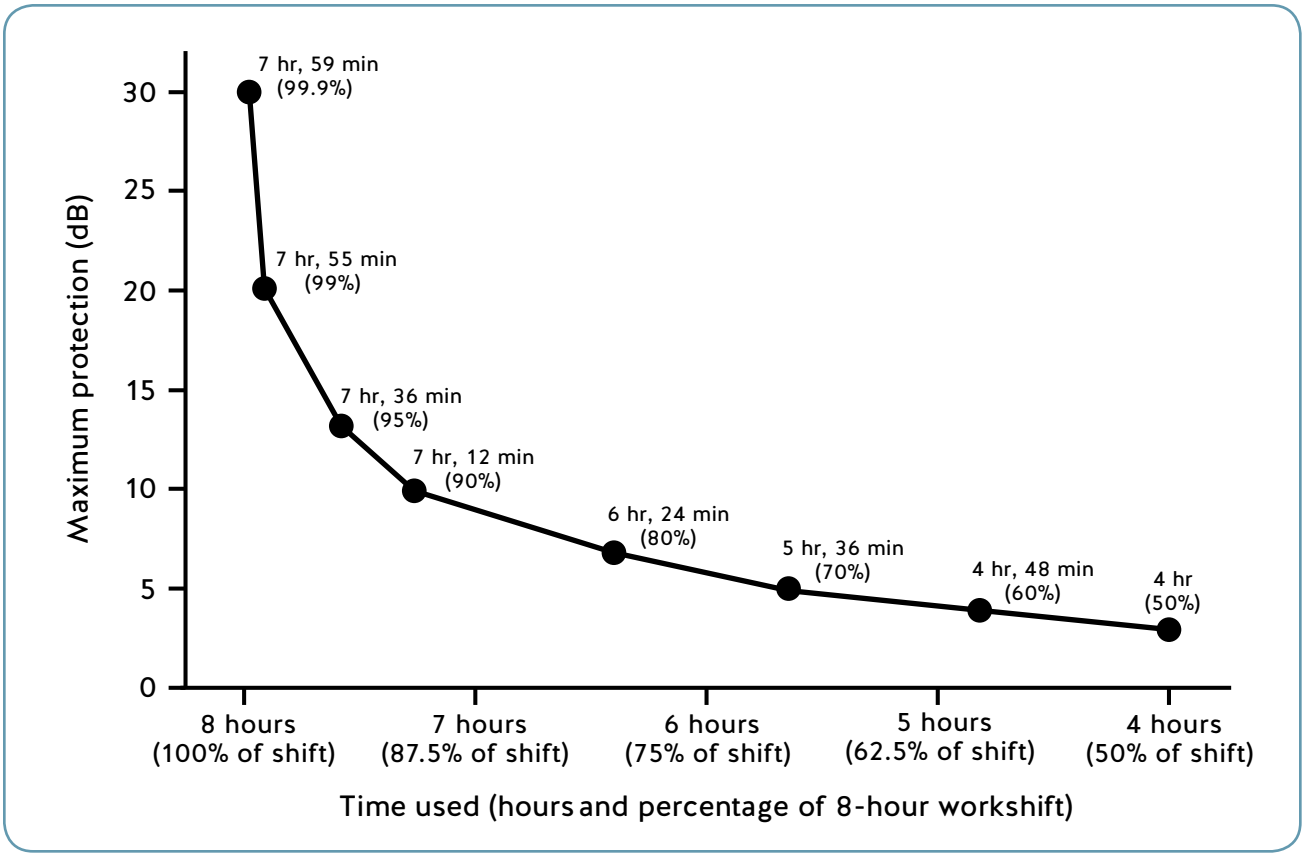
This means the faller can assume that hearing protection with an NRR of 30 will provide optimal protection in this situation. (See the "Protection outcomes" table on page 34.)

Continuous use versus non-continuous use

Sound-reducing ability alone does not determine the effectiveness of a hearing protector. Attenuation and how long a worker wears the protector are also important. If a worker finds the hearing protector uncomfortable or can't communicate with co-workers when wearing it, the worker is more likely to remove the hearing protector.

To get full benefit, workers have to wear hearing protectors all the time during noisy work. If workers remove hearing protectors, even for short periods, the protection is substantially reduced. The following graph shows maximum protection amounts for non-continuous use of an ideally fitted, 100% efficient hearing protector that can provide 30 dB of protection. For example, if a worker removes this hearing protection for just five minutes during an eight-hour shift, the maximum protection will drop to 20 dB. (Five minutes is one percent of an eight-hour shift, so in this example the hearing protection is used for 99% of the entire shift.)

Decrease in effectiveness of hearing protection when not used for full 8-hour shift*



* Based on a 3 dB exchange rate and hearing protection that can provide 30 dB of attenuation.

The need to wear protectors continuously to get full benefit means Class A protectors are not necessarily the best option if they're removed during the shift. They simply offer the most attenuation of the three classes.

Effective protection versus overprotection

The goal of wearing hearing protectors is to achieve acceptable or optimal protection. Hearing protection should reduce a worker's exposure to below 85 dBA, but not below 70 dBA. If the exposure is reduced to below 70 dBA, then the worker's hearing protection has too much attenuation. This "overprotection" leads to a feeling of isolation. Overprotection may significantly alter speech, machinery noises, or warning signals, affecting productivity or safety.

Class A protection is not recommended for workers whose noise exposure is less than 95 dBA. Hearing-impaired workers, in particular, resist wearing Class A protection because it makes them unable to hear warning signals or speech. For such workers, Class B protection or specialized hearing protection devices are often more acceptable and more likely to be consistently worn.

Protection outcomes at various sound levels

Sound level at the ear while using the protector (dBA)	Protection outcome
More than 85	Insufficient
80–85	Acceptable
75–80	Optimal
70–75	Acceptable
Less than 70	Overprotection

Comfort

Comfort is as important as attenuation when selecting hearing protection. The more comfortable hearing protection is, the more likely workers will use it consistently. Comfort factors for earplugs include the size and shape of the plugs and how well they fit in the worker's ear canal. Comfort factors for earmuffs include headband tension, cushion pressure and characteristics, and weight.

Compatibility with other PPE

Many workers who are required to wear hearing protection also wear other PPE. It's important for the combination of PPE to be comfortable. For example, workers wearing respirators, hard hats, and safety glasses may prefer earplugs to earmuffs.

Hearing ability of workers

Workers with normal or near-normal hearing can wear any class of protector. Hearing-impaired workers may find hearing protection that greatly reduces noise levels unacceptable. Reduced ability to hear warning signals, equipment sounds, or verbal instructions may make it difficult for these workers to perform their jobs safely and efficiently. Hearing-impaired workers may benefit from specialized hearing protection (see pages 29–30).

Communication demands on workers

For workers with normal hearing, protectors often make it easier to hear speech while in a noisy environment. For workers with hearing loss, however, hearing protection that greatly reduces noise levels may make speech hard to understand.

Anatomical variations

Some workers may have ear canals that are too small for earplugs or ears that are too large for earmuffs. To be effective, hearing protection must fit a wide range of head sizes or ear canal sizes. If earplugs are used, the employer must provide a variety of shapes and sizes for fitting purposes. Employers must also make earmuffs available in a variety of shapes and sizes to accommodate ears, cheekbones, and heads of different sizes and shapes.

Environmental factors (temperature and climate)

Workers often wear earmuffs in low temperatures because they're warmer than earplugs. Workers may prefer earplugs in high temperatures or high humidity because sweating can make earmuffs uncomfortable. Sweat covers can improve comfort, but depending on the material, the attenuation of the earmuffs can be compromised.

Physical constraints of workers or work activity

Workers with chronic external ear infections should wear earmuffs rather than earplugs. Workers with skin problems around the ear, such as dermatitis or eczema, should wear earplugs. For workers who do a lot of bending over and straightening, or manoeuvring in small places, earplugs may be a better choice than earmuffs.

Other factors

Many workers have strong preferences for the type of hearing protection they use. They are less likely to wear hearing protection if they don't like it or feel comfortable with it. Convenience and accessibility are also important. For example, a worker may want to remove earplugs temporarily when a noisy machine such as a chainsaw is shut off. But it can be inconvenient to have to dig the earplugs out of a shirt or pants pocket to reinsert them. It may be handier to use earplugs connected to a cord or band that hangs around the worker's neck when they're not in use.

Employers should allow workers to help choose a type of hearing protection that fits well and is comfortable, as well as being effective. Because there is no one hearing protector that's appropriate or acceptable to all workers, you must offer a variety of hearing protection.

If you're concerned about monitoring the use of hearing protection by workers, earmuffs are more easily visible.

All-plastic earmuffs or earplugs may be necessary when contact with an electrical hazard is possible.

Using and maintaining hearing protection

For more information on the use and maintenance of hearing protection, see *CSA Standard Z94.2-14*, contact the distributor, or contact WorkSafeBC's Hearing Loss Prevention Section (see page 50).

Once you've selected appropriate hearing protection, it should be individually fitted to each worker. This will ensure it's the right size and shape and that workers understand how to use it correctly. If worn incorrectly, hearing protection can be ineffective and uncomfortable, and workers may remove it. Workers' feedback on hearing protection can help you ensure it remains effective.

Employers must supply enough hearing protection or replacement parts to ensure workers wear only well-maintained hearing protection. Damaged earplugs must be replaced. New parts are available for earmuffs if domes, cuffs, or liners are damaged.

Before using hearing protection, it should be checked for flaws or damage and replaced if there are deficiencies. Cleaning hearing protection properly will maximize its lifespan. This section includes information on caring for and fitting hearing protection.

Earplugs

Some compressible earplugs can be washed and reused when dry, although they are usually thrown away at the end of a shift. Reusable custom-moulded earplugs and pre-moulded earplugs need washing at least once a week to remove wax buildup, which may reduce attenuation. Plugs should be washed at the end of the workday so they have time to dry completely. Use only hand soap and warm water for washing. Harsh detergents, solvents, or alcohol will damage the plugs.

Most earplugs come with a carrying case for storage. Reusable plugs should last six months to one year. Custom-moulded plugs should last two to five years.

Earmuffs

Earmuff domes generally only need to be wiped with a damp cloth. The hard-plastic domes should last about two years.

Skin oil, perspiration, and some hair preparations harm the effectiveness of cuffs. After frequent use, the soft cuffs become hard and can even shrink. Replaceable cuffs are available for most

earmuffs. Cuffs should be replaced every six months. Check liquid-filled cuffs often to make sure the liquid is still present. Replace leaking cuffs.

Keep the liner material inside the domes clean. If the liners are discoloured, hardened, or extremely soiled or mildewed, replace them. Ozone emissions from generators and some welding operations can cause the liner material to disintegrate and also harden the seals.

Earmuffs need to be tight enough to form a good seal. If adjusting the headband is no longer enough to keep the muffs tight and maintain adequate pressure, replace the headband.

Storing earmuffs

Hang earmuffs by the headband on a hook in a well-ventilated area. Don't throw them into a toolbox or truck bed — that can lead to cracked domes, ripped cuffs, or bent headbands.

Don't leave earmuffs outdoors where bees, wasps, and spiders can make homes inside them.

For earmuffs mounted on hard hats, don't store the muffs with the cuffs pressing against the hard hat. This constant pressure on the cuffs can quickly flatten them. Instead, keep the earmuffs raised off the hat or snapped out when not in use.

Fit-testing systems

Fit-testing systems (also known as field-attenuation estimation systems or FAES) help assess individual hearing protection performance. Fit testing provides a more accurate estimate than the NRR or class for the protection a worker can expect with a given hearing protector. Fit-testing systems use various methods to obtain individual fit-test data, also known as personal attenuation ratings.

The use of a fit-testing system does not replace the selection and fitting criteria described in "Selecting hearing protection." Fit-testing systems are meant to be used on individual workers as a training tool to help with the selection and fitting of hearing protection.

Posting the noise hazard

Where engineering controls can't reduce noise levels to, or below, the exposure limits, warning signs must be posted to let workers know that hearing protection must be worn in that area.

Signs such as this WorkSafeBC poster can be useful for telling workers they must wear hearing protection in a particular work area.

You don't need to post the actual measured noise levels. Also, warning posters and signs shouldn't specify which class of hearing protection must be worn, based on the noise level measured in an area. Hearing protection should be determined for each worker, based on the selection criteria in *CSA Standard Z94.2-14*. The worker's daily noise exposure (not the area noise level) is only one factor that must be considered.

For warning posters and signs you can download and print, go to worksafebc.com and click "Forms & Resources." Under Type, select "Posters & signs," and then search for "hearing."

Hearing testing

Once a hearing conservation program is in place, the only way to ensure it's effective is to measure workers' hearing periodically. Hearing tests are required for workers exposed to noise greater than 85 dBA for eight hours.

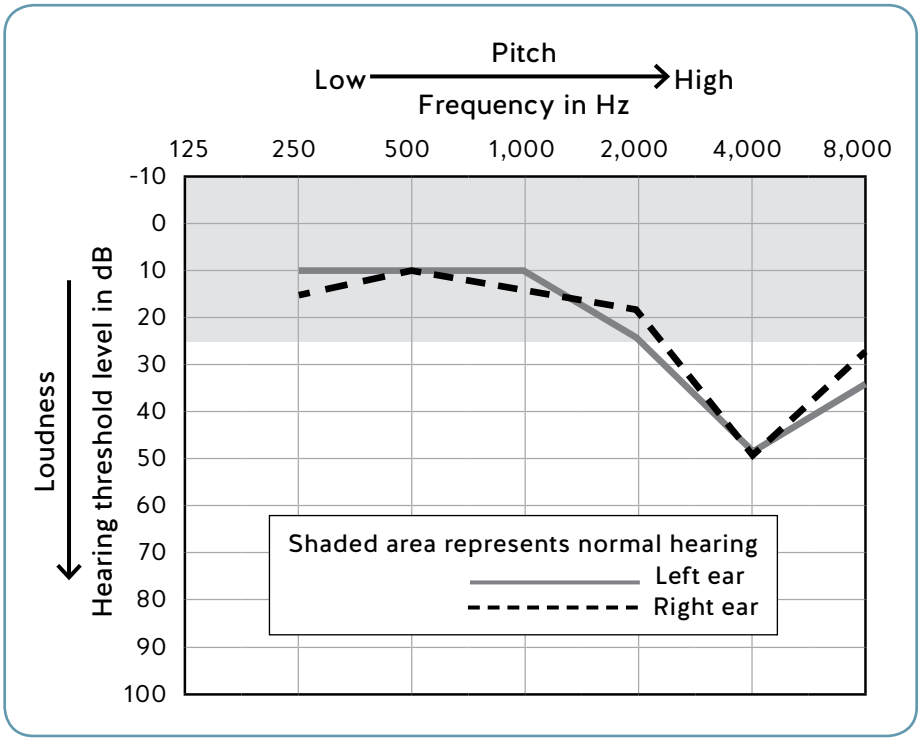
Hearing tests are vital because they identify noise-induced hearing loss long before workers notice it. As part of the test, each worker should be counselled about the test results, the follow-up required, and when a repeat test will occur.

Employers must ensure that workers receive an initial hearing test as soon as practicable after employment starts, but no later than six months after hiring. You must also ensure that tests are done annually to monitor the hearing of noise-exposed workers. The hearing test, including counselling, takes 15 to 20 minutes.

What does a test consist of?

During a test, the worker sits in a sound booth wearing earphones. An audiometric technician sends a series of tones through the earphones to one ear and then the other. The worker signals the technician as he or she hears the tones. The technician records the worker's responses for each ear and then charts the results on a graph called an audiogram.

The audiogram shows how loud a tone needs to be for the worker to barely hear it at different pitches or frequencies. In the early stages of noise-induced hearing loss, the audiogram will show some hearing loss for high-pitched sounds. As hearing loss advances, the audiogram will show hearing loss for many pitches. Workers with more advanced hearing loss will notice speech and surrounding sounds are muffled.



Audiograms are graphs that show hearing levels for sounds at various pitches. They show the quietest level that a person can hear for each pitch, which is measured in hertz. The sound level, measured in decibels, is labelled along the left side of the graph. It goes from quieter at the top of the left axis to louder at the bottom. The better someone's hearing is, the higher the points will be on the graph.

Who performs the hearing test?

Hearing testing and counselling must be performed by a trained and authorized audiometric technician. Technicians must complete a training course and attend periodic refresher classes to maintain their authorization. For more information on training and authorization, go to worksafebc.com and search for "annual hearing testing" or "audiometric certification."

Industrial audiometric technicians are responsible for the following:

- Perform the hearing test.
- Categorize the test results.
- Counsel workers on the state of their hearing and compare the results with previous tests whenever possible.
- Advise workers on appropriate hearing protection.
- Submit hearing-test results to WorkSafeBC.
- Provide copies of hearing-test results to the employer and, if the employer agrees and signs a written release, retain copies for future reference.
- Maintain the audiometric equipment.

Testing options

Employers have several options for testing workers. You can set up an in-house facility, send workers to another company's testing facility, or hire a hearing-test company, also known as an industrial audiometric business (IAB). IABs often use mobile units they can bring to the worksite. Otherwise, workers need to go to the IAB premises for testing.

In-house testing

Employers can select one or more employees to be trained as industrial audiometric technicians and install a hearing-test booth and testing equipment. An in-house program has some advantages over the other options. One is having an on-site technician who is familiar with company policy and is available to answer questions on hearing protection and hearing loss. The technician can also re-test workers who have unreliable or unusual audiograms.

Another advantage is ease of scheduling. Tests can be spread out over the year at the employer's convenience. Scheduling tests with an IAB contractor over one or two days can disrupt the workday, and workers who are away may be missed.

Equipping an in-house facility is expensive, so in-house testing is generally better suited to a large company with many noise-exposed workers. Smaller companies may wish to send workers to a nearby employer's facility or schedule tests with an IAB contractor.

Industrial audiometric business testing

Many companies throughout B.C. supply hearing testing and counselling on contract. These companies have facilities that meet WorkSafeBC minimum standards. They also often have mobile testing facilities they can bring to an employer's worksite. IAB technicians are trained and authorized to conduct hearing tests. For a list of authorized IAB contractors, go to worksafebc.com and search for "industrial audiometric testing."

Employers must be aware of the IAB's responsibilities. IABs are responsible for the same duties as in-house technicians, as well as the following:

- Have an approved testing facility and authorized audiometric technician.
- Choose an appropriate site for hearing tests.

- For mobile facilities, use an approved noise monitor. The noise monitor alerts the technician if allowable noise levels inside the test booth are momentarily exceeded, so the technician can stop the testing until acceptable noise levels resume.

When hiring an IAB contractor, employers must do the following:

- Select a company representative to act as a liaison among the company, the workers, the IAB technician, and WorkSafeBC.
- Establish a schedule for the hearing tests.
- Inform workers about the hearing conservation program. (See the WorkSafeBC information sheet *Testing Your Hearing: How and Why*.)
- Help the IAB technician find a suitable area for the mobile testing facility, if applicable.
- Provide a list and samples of hearing protection supplied to workers.
- Ensure the technician counsels each individual worker privately about his or her test results.
- Maintain records of the hearing tests. WorkSafeBC makes the results of past tests available to employers. Go to worksafebc.com and search for "annual hearing testing."
- Regularly review hearing-test data to ensure the program is effective.

Hearing-test results

The first hearing test a worker has is called the baseline test. The results are categorized as follows:

- **Normal test** — normal or near-normal hearing
- **Early warning test** — the start of noise-induced hearing loss
- **Abnormal test** — significant hearing loss requiring medical follow-up, but does not appear to be caused by noise exposure

Repeat tests are called periodic tests. They are categorized as follows:

- **Normal-change test** — no significant change from previous test; hearing has remained stable
- **Early warning-change test** — there has been a high-frequency deterioration in hearing, likely due to noise exposure
- **Abnormal-change test** — significant change from the previous test requiring medical follow-up, but not likely due to noise exposure

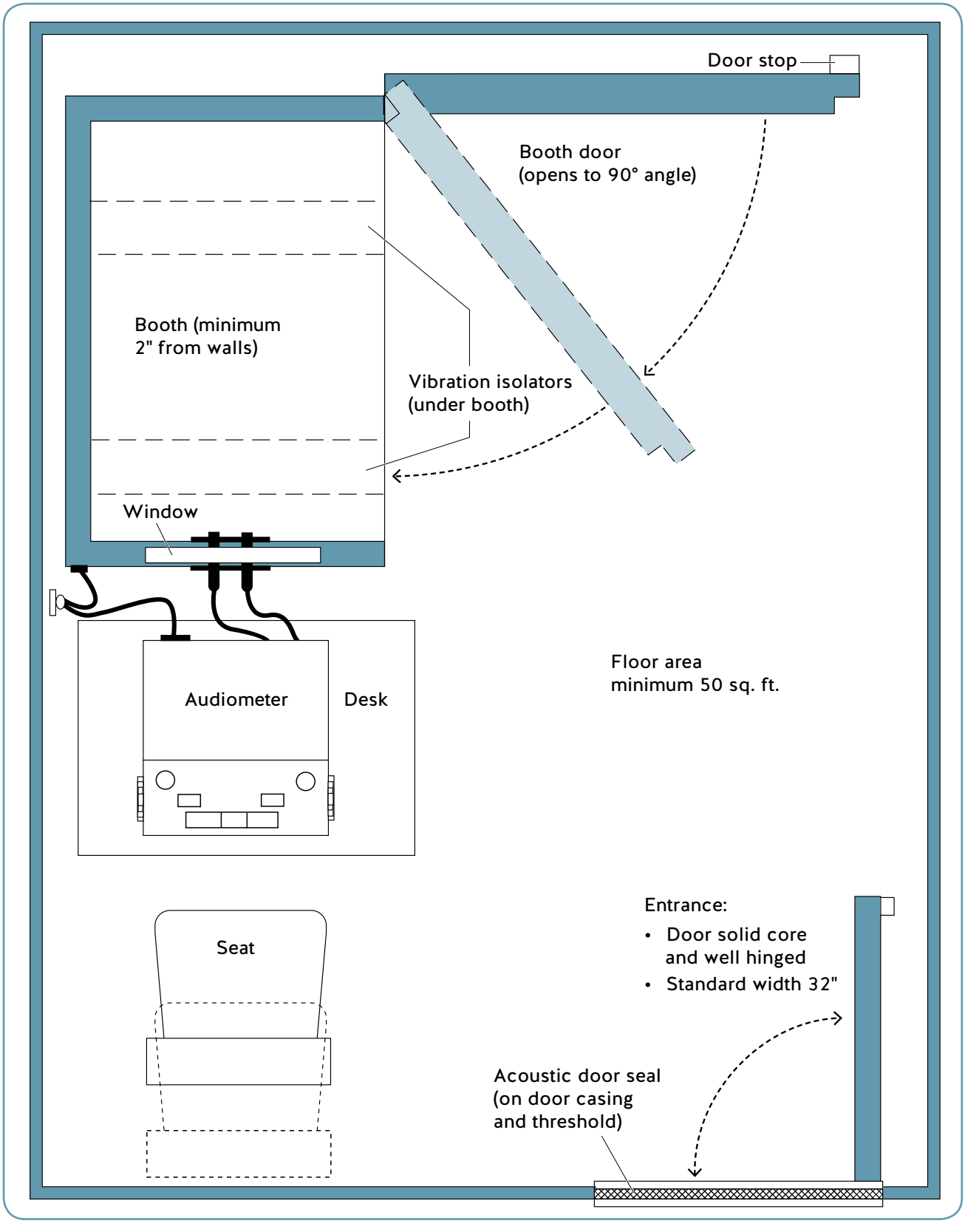
The technician is not qualified to determine the possible causes of abnormal or abnormal-change hearing tests. The tests themselves don't provide enough information to make a diagnosis. Medical follow-up and further testing is required to determine possible causes.

Requirements for hearing-test facilities

Hearing-test facilities need to meet certain minimum requirements as specified by WorkSafeBC so test results will be reliable. For information on the requirements for hearing-test facilities, see the WorkSafeBC publication *Industrial Audiometric Facility Approval Process* as well as *CSA Standard Z107.6-16.*

The hearing-test facility must have an audiometric sound booth and an audiometer. There must be privacy for counselling and no distractions for workers or technicians. The illustration on page 45 shows a typical layout for a hearing-test facility.

Hearing-test facility (acceptable layout)



Requirements for hearing-test facilities are specified in the WorkSafeBC publication *Industrial Audiometric Facility Approval Process* and in *CSA Standard Z107.6-16*.

Hearing-test records

Employers must have hearing-test records for each worker for the duration of their employment. You can keep hard- or soft-copy records, or retain them in the WorkSafeBC database. To access test results, go to worksafebc.com and click "Log in/Create an account."

These records must be available for comparison with each new hearing test. Comparisons help technicians determine how to categorize the hearing-test results and what counselling the worker needs.

Hearing-test records are confidential. If an IAB keeps records on your behalf, you must provide a written release.

WorkSafeBC also keeps hearing-test records sent by audiometric technicians. The records include a brief medical history of the worker, which is part of the baseline test. Employers don't have workers' medical histories.

WorkSafeBC records have been valuable for investigating trends in noise-induced hearing loss and the use of hearing protection by B.C. workers. Information from WorkSafeBC records is not available to anyone except in the form of statistical analysis. The only exception is that workers may authorize (in writing) the release of their records (for example, to a family doctor or for a WorkSafeBC claim file).

Hearing tests in the construction industry

All employers are responsible for paying for their workers' hearing tests. However, for construction employers the cost of hearing tests is included in their WorkSafeBC assessments. This means construction employers don't pay the IAB at the time of the test.

Construction workers are supplied with "Record of Hearing Test" cards that they must have with them at all times. When workers go to a new jobsite they must be able to show that they've had an annual hearing test.

Annual review of hearing conservation program

Employers must review the hearing conservation program once a year to make sure it's effective. This annual review should address the following:

- **Hearing-test information on the rate and extent of occupational hearing loss** — Even when you provide hearing protection, it can fail to prevent hearing loss for a number of reasons, including improper fit, poor maintenance, and inconsistent use. Hearing-test statistics will indicate whether noise-related hearing loss is still occurring. You can access test results by going to worksafebc.com and clicking "Log in/Create an account."
- **Adequacy of noise-control measures** — Consider technological advances that could reduce noise levels even further. When purchasing new equipment, you should specify low noise levels. Also, ensure that equipment is maintained to prevent worn and unbalanced parts, which can cause increased noise and vibration.
- **Need for further noise measurement** — Changes in the workplace, such as expansion or new processes, could change noise levels.
- **Education and training of workers** — Ensure that workers understand the risks of noise overexposure. Workers must use and maintain hearing protection correctly.
- **Selection and use of hearing protection** — The reviewer should ask for worker opinions on the hearing protection they're currently using. Does the protection interfere with other PPE? Does it make communication difficult? Is it comfortable?

A Hearing Conservation Program Checklist (see pages 48–49) can help you review your program. The coordinator of the program can use the checklist to determine if all the necessary components are in place and documented.

If there is a joint health and safety committee or worker health and safety representative, you should ensure that the committee or representative participates in the program review.

Hearing conservation program checklist

1. Noise measurement

- ☐ Representative noise-exposure levels have been determined for all noise-exposed workers, as specified in *CSA Standard Z107.56-13.*
- ☐ Warning signs indicating that hearing protection is required are posted in noisy areas.
- ☐ A report of the noise-survey findings is available for review, unless an exception applies.

2. Education and training

Noise-exposed workers have received education on:

- ☐ The results of noise-exposure measurements
- ☐ Effects of noise on hearing
- ☐ Proper fit, use, and maintenance of hearing protection
- ☐ Purpose of hearing testing

Staff responsible for administering the program have:

- ☐ Received education on hearing loss to understand the program goals and policies, and training in the use and fitting of hearing protection

3. Noise control

- ☐ Major noise sources and options for engineering and administrative controls have been identified.
- ☐ Where practicable, noise-control solutions have been implemented.
- ☐ There is a noise-control maintenance plan.
- ☐ There are specifications for the purchase of noise-control equipment.
- ☐ New facility planning includes noise control.
- ☐ If possible, shifts have been altered to reduce the duration of noise exposure.

4. Hearing protection

- ☐ The use of hearing protection is consistently enforced.
- ☐ Hearing protection is selected as specified in *CSA Standard Z94.2-14.*
- ☐ Each worker is individually fitted with hearing protection and trained in its use and care.
- ☐ Hearing protection is replaced regularly.
- ☐ Hearing protection is inspected for condition, fit, and correct placement.

5. Posting the noise hazard

- ☐ Warning signs are posted in all areas where noise hazards exist.
- ☐ Signs indicate that all workers must wear hearing protection in these areas.

6. Hearing tests

Employers who contract an IAB:

- ☐ The mobile hearing-test facility is in a suitably quiet location.

Employers using an in-house program or a contracted IAB:

- ☐ Workers are privately and individually counselled on the hearing-test results, as well as the use and care of hearing protection.
- ☐ The employer maintains confidential records of hearing tests.
- ☐ All noise-exposed workers are tested annually.
- ☐ Test results are submitted to WorkSafeBC.

7. Program review

- ☐ The hearing conservation program addresses the seven elements specified in the Regulation.
- ☐ The effectiveness of the program is reviewed at least annually.
- ☐ An action plan addresses identified deficiencies.
- ☐ The action plan is implemented and documented.
- ☐ Review results are shared with the joint health and safety committee (or worker health and safety representative).

The review addresses the following:

- ☐ Need for further noise measurement
- ☐ Education and training
- ☐ Adequacy of noise-control measures
- ☐ Selection and use of hearing protection
- ☐ Hearing-test data on rate and extent of noise-related hearing loss

WorkSafeBC resources

WorkSafeBC has a variety of resources for noise control and hearing conservation. Go to worksafebc.com and search for "hearing loss" and "hearing conservation," or search for the following specific titles:

- *Basic Noise Calculations* — This document explains how occupational noise measurements can be refined and used to calculate noise-exposure levels.
- *Hear for Good* — This pamphlet provides basic information on hearing protection for workers.
- *The Hearing Video* — This video (also available on YouTube) describes the effects of noise on hearing, the use and care of hearing protection, and the purpose of hearing testing.
- *How Loud Is It?* — This is a series of bulletins for various industries and municipalities.
- *Industrial Audiometric Facility Approval Process* — This document provides information on the requirements for hearing-test facilities.
- *Industrial Audiometric (Hearing Test) Businesses* — This information sheet lists authorized IABs. It includes mobile facilities and fixed-location facilities.
- *Occupational Noise Surveys* — This technical document provides information on how to perform noise surveys and how to report results.
- *Testing Your Hearing: How and Why* — This publication describes hearing testing for workers.

Hearing Loss Prevention Section

Staff from the WorkSafeBC Hearing Loss Prevention Section can provide information on hearing conservation. They also have lists of authorized IAB contractors and suppliers of sound-level measuring equipment, audiometers, and booths.

The Hearing Loss Prevention Section authorizes industrial audiometric technicians to test hearing and provide advice on the proper use and care of hearing protection. For more information, call the WorkSafeBC Prevention Information Line.

Prevention Information Line

604.276.3100 in the Lower Mainland
1.888.621.7233 (621.SAFE) toll-free in Canada

Terms

Decibel A-weighted (dBA)

A unit of sound-pressure level measured with an A-weighting filter.

Decibel C-weighted (dBC)

A unit of sound-pressure level measured with a C-weighting filter.

L_{eq}

The equivalent steady sound level of a noise energy, averaged over time.

L_{ex}

Also known as noise-exposure level. The sound-level energy, averaged over eight hours, that would give the same daily noise exposure as the varying noise over a typical full shift.

Peak sound-pressure level

The peak instantaneous pressure expressed in dB and measured on a sound level meter that has a peak-hold capability.

3 dB exchange rate

When sound energy doubles, the dB level increases by 3.

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